EPA Workshop on Gasoline Sulfur Levels

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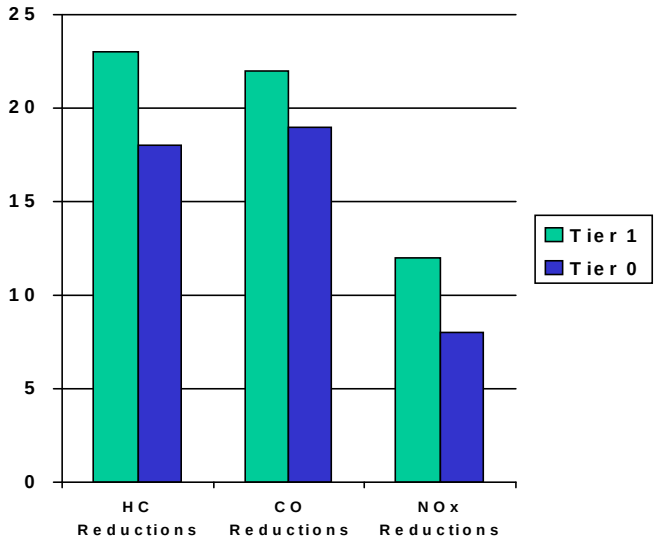
Purpose of the EPA Workshop on Gasoline Sulfur Levels

- The purpose is to find the most cost effective way to provide clean air benefits
- EPA must consider the emissions benefits from the existing fleet as well as new low emissions vehicles
- The purpose is not:
  - to determine whether vehicles meet their certification standards when operated on “real-world” fuels
  - related to NLEV
  - for EPA to “share the burden” of clean air regulation

Auto/Oil Sulfur Results



- Reducing sulfur from 450 to 50 ppm reduced HC, CO, and NOx emissions by 18-23%, 19-22%, and 8-12% respectively
- “Tier 1” vehicles showed a greater effect than “Tier 0”
- AQIRP Final Report

Sulfur Effects on Current and Near-Term Future Vehicles

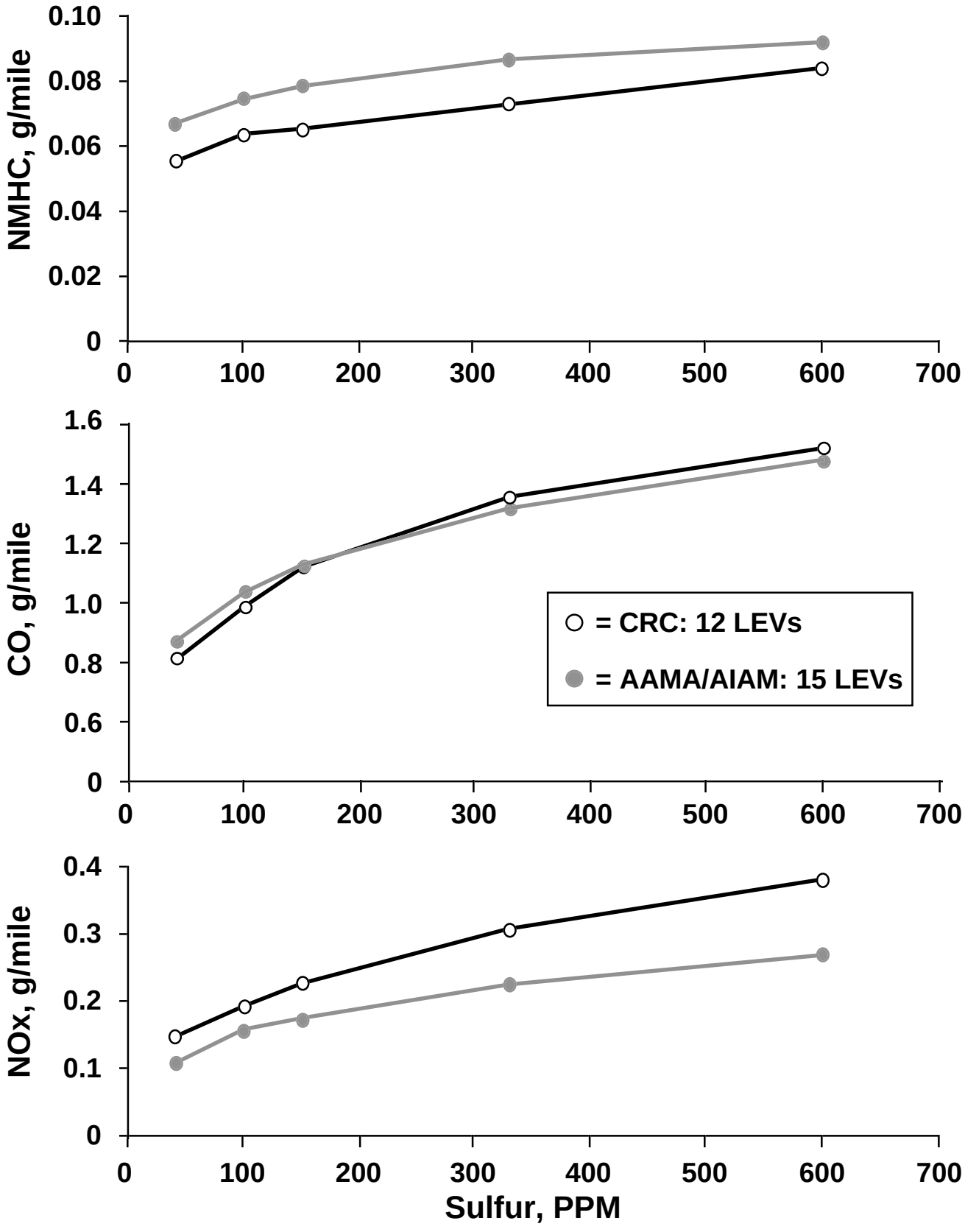
- CRC and AAMA/AIAM conducted independent studies on the effects of sulfur on LEV and ULEV vehicles
- Base Fuels were similar and sulfur levels ranged from 40 to 600 ppm
- **Every** vehicle tested experienced large and statistically significant increases in NMHC, CO, and NOx

AAMA/AIAM vs. CRC Program Comparisons

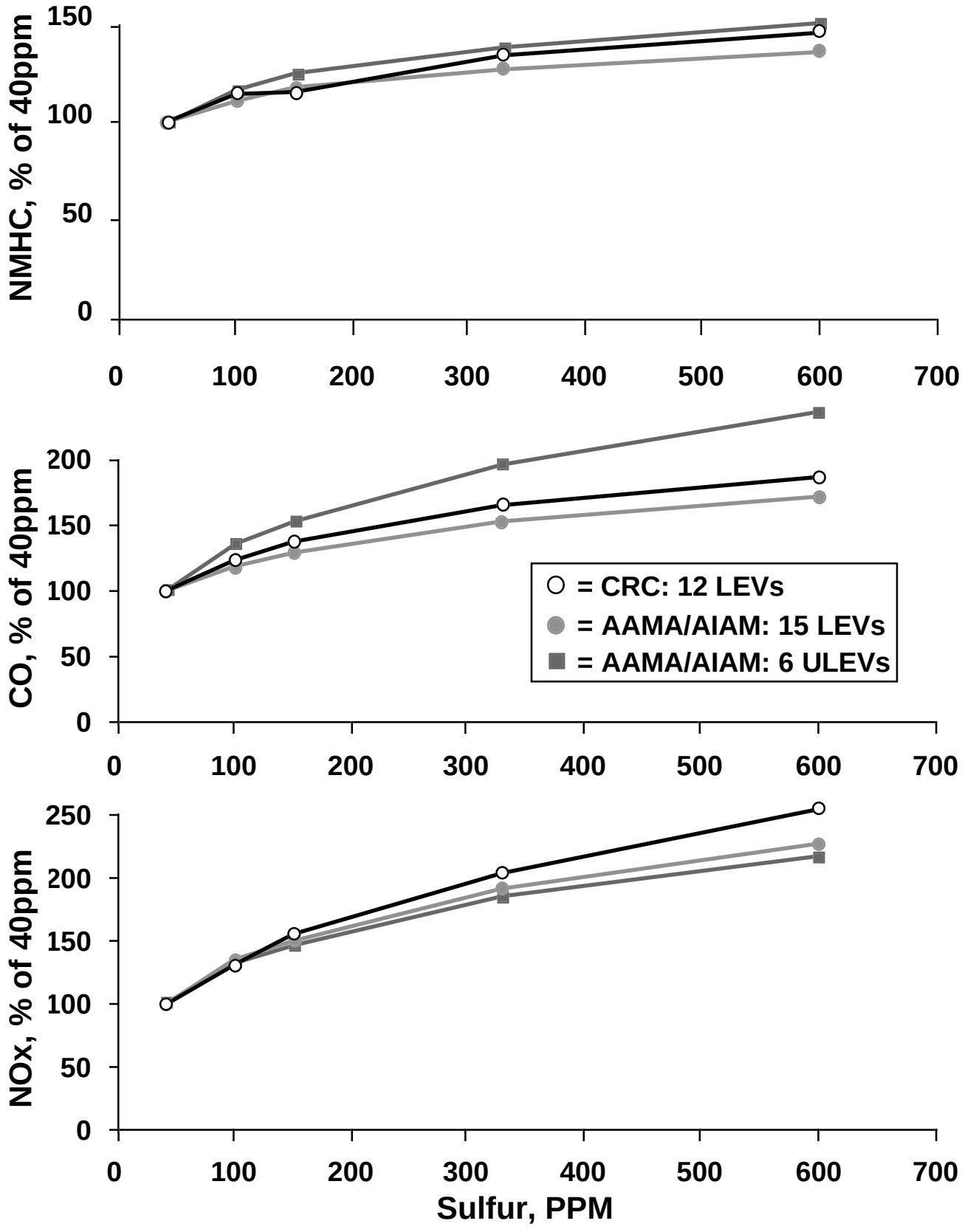
- CRC
  - 12 Vehicles, 6 models, 5 OEMs
  - 4- and 8-cyl production LEVs
  - As received (10K miles) and 100K aged
  - Non-oxy Industry Ave Fuel at 40, 100, 150, 330, and 600 ppm S
  - California CBG at 40 and 150 ppm S
- AAMA/AIAM
  - 21 vehicles, 21 models, 10 OEMs
  - 4-, 6-, and 8-cyl PC, LDT1, LDT2, and LDT3
  - 15 LEV Production/Production Intent
  - 6 ULEV Production/Production Intent
  - 50K or 100K Aged
  - California CBG at 40, 100, 150, 330, and 600 ppm S

Comparison of Sulfur/LEV Programs Means From Ln-Ln Transformation: Aged Catalysts

(Maximum Likelihood Estimates)



Comparison of Sulfur/LEV Programs
Percent Change from Base Fuel: Aged Catalysts
(Maximum Likelihood Estimates)

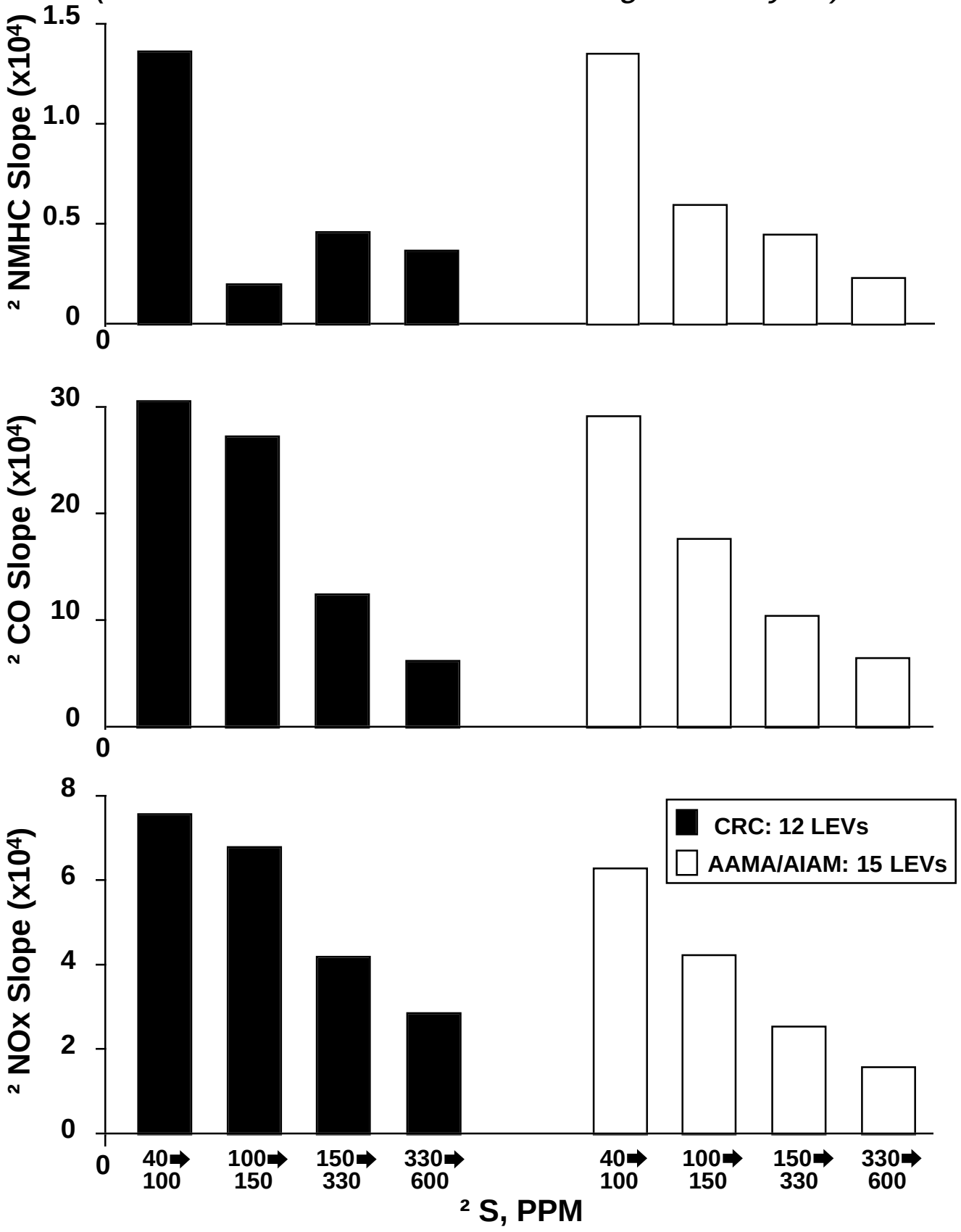


Comparison of LEV/Sulfur Test Program Results
LEV Fleet Sulfur Effects
FTP Composite Results with Aged Components

	CRC	AAMA/AIAM
600 → 40 ppmS		
NMHC	- 32%	- 29%
CO	- 46%	- 47%
NOx	- 61%	- 58%
40 → 600 ppmS		
NMHC	+ 46%	+ 41%
CO	+ 86%	+ 88%
NOx	+156%	+133%

Comparison of Sulfur/LEV Programs
Change in Emissions Vs. Change in Sulfur

(Maximum Likelihood Estimates-Aged Catalysts)



There are No “Sulfur-Tolerant” Platinum Group Metal Catalysts

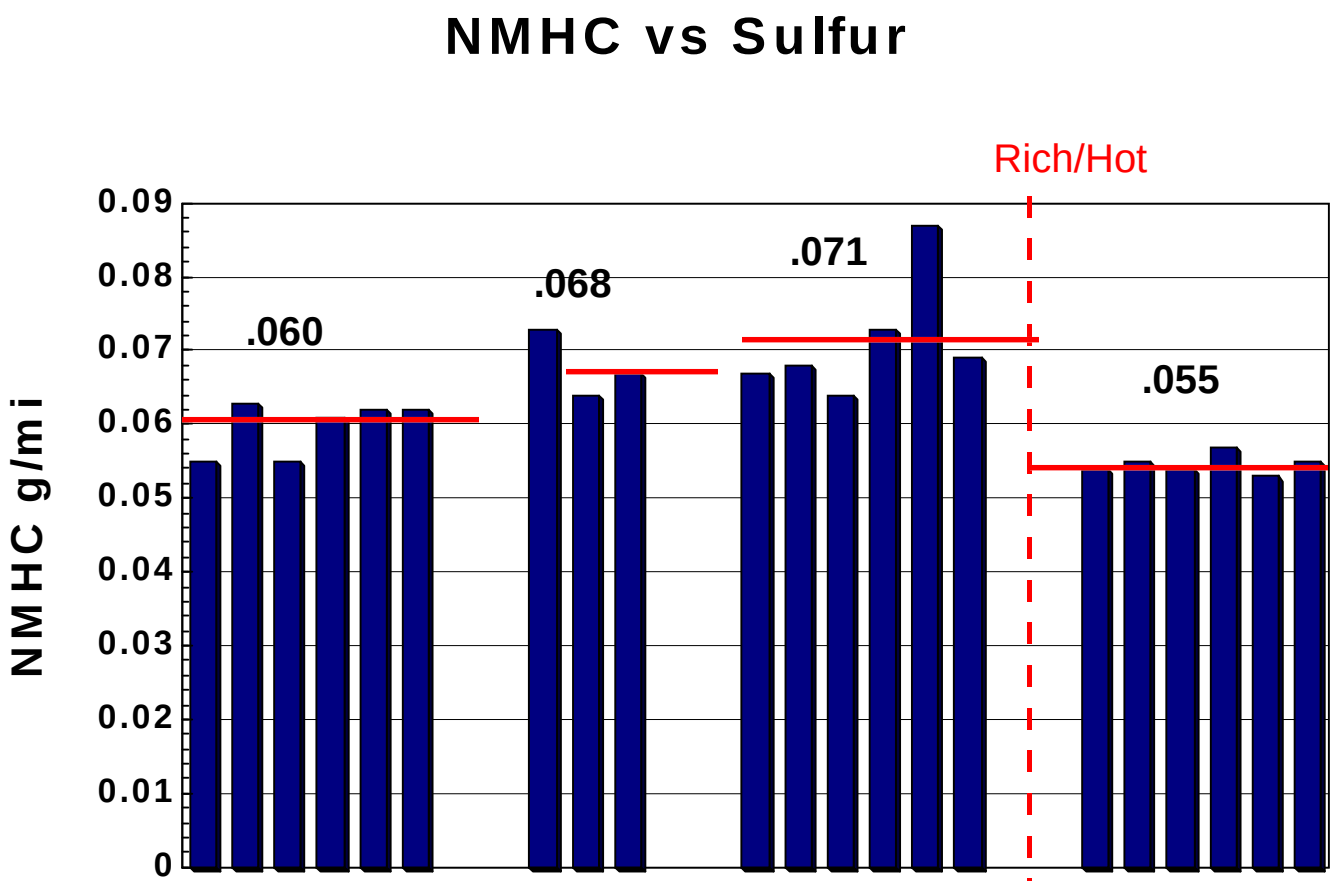
- Catalytic reforming has been used by the refining industry for 50 years
  - Despite the cost of reformer feed desulfurization and years of research, reformer feed is still hydrotreated to less than 0.5 ppm sulfur before being exposed to the platinum-based reformer catalyst
  - Even at that, the reformer catalyst cannot be regenerated (sulfur poisoning reversed) under routine operation. The catalyst must be taken off-line, at great expense, for poisoning reversal.

The Reversibility of Sulfur Poisoning of Automotive Exhaust Catalysts

- Chrysler research shows that reversibility is not achieved under FTP conditions in a LEV-calibrated Neon
- High catalyst temperatures and rich air/fuel ratios are needed to reverse sulfur poisoning
- SFTP will limit rich air/fuel operation
- Because LDTs are designed for maximum catalyst temperatures during towing and heavy work, their catalysts will not be hot enough for reversibility during routine operation
- The lack of sulfur-poisoning reversibility means that national, year-round sulfur control is critical

Sulfur Reversibility Study

Production Intent Chrysler LEV
Multiple Cold FTP Results



- ✓ **NMHC sulfur memory effect of 100%. The highest sulfur level the vehicle is operated on may define the TP HC emission levels when rich/hot operation is constrained.**

Other Gasoline Sulfur Issues

- EPA recognizes in its 211(l) regulations that sulfur is a significant contributor to engine deposits. Lower gasoline sulfur could reduce gasoline detergent levels and their side effects (combustion chamber deposits), as well as reduce costs
- Gasoline sulfur contributes to vehicle particulate and SOx emissions
- “Rotten egg” odor of vehicle exhaust is caused by high sulfur levels, and is a significant customer complaint

U.S. Gasoline Sulfur Levels Preclude the Introduction of Advanced Vehicle Technologies

- The use of lean NOx catalysis is necessary for the introduction of direct injection gasoline engines to the U.S.
- “Relatively small amounts of sulfur dioxide may severely suppress the NOx adsorption activity of the catalyst.” -- DeGussa AG, SAE 962047

Other Fuel Issues

- In its staff paper, EPA recognizes the need to control gasoline volatility parameters. Current and proposed ASTM volatility parameters will require compromises of air/fuel calibrations (higher emissions) to assure customer satisfaction on marginal fuels
- Current engine deposit requirements under 211(l) are inadequate to ensure service-life emissions performance or customer expectations, and do not even consider combustion chamber deposits
- Diesel fuels for both light and heavy duty applications will likely require the same sulfur levels (30 ppm) as gasoline

Conclusions

- Sulfur is an exhaust catalyst poison which has a much greater effect on LEV and ULEV systems than tier 0 and tier 1 vehicles
- No sulfur tolerant vehicle was found in either the CRC or AAMA/AIAM research programs
- The reduction of gasoline sulfur levels will have immediate benefits for the existing vehicle fleet
- The full emissions-reduction benefit of the NLEV program will not be realized with current 49-state sulfur levels
- The effects of sulfur on exhaust catalysts in the future is unlikely to be reversible